School of Sciences

Certificate

I hereby declare that the synopsis **"Statistical Exploration of Human Fertility Dynamics in context of India"** being submitted in partial fulfilment of the requirement for the degree of Doctor of Philosophy in Statistics under school of Sciences of U.P. Rajarshi Tandon Open University, Prayagraj during the academic year 2024-25.

It is a Bonafide record of original work carried out under the supervision of Prof. / Dr. Shruti and has not been submitted in full or part to any other university or institute for a degree or diploma. Further, it is certified that the short synopsis is plagiarism-free, and the report has been submitted.

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Statistical Exploration of Human Fertility Dynamics in Context of India

MODIFIED SYNOPSIS

Submitted in partial fulfillment of the requirement of the degree of

DOCTOR OF PHILOSOPHY IN STATISTICS

to

U.P. Rajarshi Tandon Open University, Prayagraj

By

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ABSTRACT

Fertility, also known as natality, is the actual reproductive performance of an individual or couple. It is defined by the numbers of live births. The human fertility analysis is very important factor in demographic analysis (study of human population), as it directly influences population growth and structure. Fertility change also is intimately linked to the processes of social and economic development. India, with its vast diversity and rapid socio-economic changes, exhibits complex fertility dynamics influenced by multiple factors such as age, education, economic status, and cultural practices. Analyzing causes and consequences of fertility change across different ages, regions, socioeconomic groups, and cultural backgrounds is important for shaping effective population policies. These valuable insights are essential for shaping reproductive health initiatives, advancing family planning efforts, promoting gender-inclusive programs, and crafting sustainable long-term development strategies.

Our study aims to statistically explore the fertility dynamics of India with its states using nationally representative data. Here we examine the fertility trends, factors that influencing the fertility behaviors and employing the statistical models. This comprehensive statistical exploration contributes to a deeper understanding of fertility dynamics in India within the framework of the Demographic Transition and offers actionable insights for policymakers, health practitioners, and researchers.

Key words: Fertility, Demographic analysis, Population growth and structure, Demographic Transition, Sustainable Development

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1.0 INTRODUCTION:

Fertility is defined by the number of live births, as it represents the actual reproductive performance of an individual. It is an important component of demography, as they directly influence the population growth and structure. The analysis of fertility patterns is important for understanding and supporting a country's broader socio-economic growth. Fertility rates influence population growth, labor force dynamics, and the demand for essential services. A country with high fertility rates can experience the huge increase in the population, which puts pressure on resources such as healthcare, education, housing, and employment. On the other hand, decline in fertility can lead to population aging, labor shortages, and higher dependency ratios.

India has historically experienced high fertility rates, contributing to rapid population growth. However, during the past few years, fertility levels have varied significantly across different states. According to the NFHS-5 report, India has achieved its fertility replacement level, indicating a shift towards population stabilization. Despite this progress, some states (particularly in northern and central) continue to experience high fertility rates. The high variability in fertility trends across states shows the need for a comprehensive study of fertility dynamics to understand regional disparities and their effects on the distribution of resources, economic planning, and social development.

1.1 Background of the Study / Emergence of the Problem:

For the developing countries, highly increase in population has been recognized as a major barrier to development since the post-World War II period [1]. Conversely, developed nations are increasingly grappling with the consequences of declining fertility rates and aging populations, which pose substantial risks to long-term economic stability and the sustainability of social welfare systems [2]. Consequently, while population control remains a key policy focus in less developed countries, developed nations are increasingly implementing strategies to encourage higher fertility in response to demographic imbalances. Fertility interventions have thus become an integral component of population policies across the globe. Since the mid-1960s, developing country governments have implemented various impactful strategies to reduce fertility rates through awareness campaigns and family planning initiatives, and reproductive health initiatives. In contrast, from the late 20th century onward, developed countries have introduced a range of pro-natalist policies such as parental leave benefits, childcare subsidies, and financial incentives to support family life and reverse declining fertility trends [3].

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World Population Prospects 2022:

As per the *World Population Prospects 2022*, India's population was estimated at 1.412 billion in 2022, slightly behind China's 1.426 billion. Together, China and India each with populations exceeding 1.4 billion account for a substantial proportion that is more than half of the global figure that resides in Asia. Although India's population growth is slowing down, it continues to increase at a rate of 0.7% annually and was projected to overtake China in 2023 to become the most populous country around the world. [4]. India has experienced an unequal demographic transition in different regions. While southern states have reached below-replacement fertility levels, the northern and eastern States: Bihar, UP (Uttar Pradesh), MP (Madhya Pradesh), Rajasthan, Jharkhand, and Chhattisgarh continue to have higher fertility [5].

Demographic Transition Model (DTM):

Fertility is a crucial component of the Demographic Transition Model (DTM), which explains how countries evolve from a phase of high to low birth and death rates as part of socio-economic development. The DTM highlights how changes in fertility and mortality influence population growth and age structure over time and focuses on population and development dynamics through fertility and mortality trends [7,8].

Table 1: Composition of Demographic Transition Model (DTM)

Stages	Demographic Transition Model (DTM)
1	**Pre transitional stage** Birth rate- High Death rate- High Little or no growth
2	**Early Transitional stage** Birth rate- High Death rate- Fluctuating High growth
3	**Late-transitional stage** Birth rate- Declining Death rate- Relatively low Slow growth
4	**Post transitional stage** Birth rate- Low Death rate- Low Very low growth

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National Family Health Survey (NFHS):

The National Family Health Survey (NFHS), conducted under the Ministry of Health and Family Welfare, Government of India(GOI), provides comprehensive and reliable data on fertility and reproductive health at the national, state, and district levels. According to NFHS-5 (2019–21), India's Total Fertility Rate (TFR) has declined to 2.0, which is below the replacement level fertility of 2.1. This indicates a major demographic shift, especially when compared to NFHS-1 (1992–93), which reported a TFR of 3.4. Five states-Bihar (2.98), Meghalaya (2.91), Uttar Pradesh (2.35), Jharkhand (2.26) and Manipur (2.17) have Total Fertility Rate (TFR) above the replacement level of 2.1 and several states and union territories, such as Chandigarh (1.4), Andhra Pradesh (1.68), Karnataka (1.67), and Kerala (1.79) have fertility rates below the replacement level [9].

Sample Registration System (SRS):

The Sample Registration System (SRS), maintained by the Office of the Registrar General of India (RGI), serves as a crucial source of demographic data, particularly for analyzing fertility trends across the country. It provides annual estimates of key fertility indicators, including the Crude Birth Rate (CBR), Total Fertility Rate (TFR), Age-Specific Fertility Rates (ASFR) etc. According to SRS data for 2021, Bihar recorded the highest birth rate at 25.6, while the Andaman & Nicobar Islands reported the lowest birth rate at 10.6. Bihar (25.6), Uttar Pradesh (24.8), Madhya Pradesh (23.8), Rajasthan (23.6), Jharkhand (21.8), Chhattisgarh (21.7), and Meghalaya (23) are states with the highest birth rates [5].

Some Fertility models:

1- Bongaarts Proximate Determinants Model:

Fertility is a continuously evolving phenomenon that changes with time and is influenced by socio-cultural and behavioral elements. Its patterns and levels are significantly shaped by a combination of demographic, physiological, cultural, socio-economic, behavioral, and environmental factors. Bongaarts (1978) has proposed a list of eight intermediate variables, termed as *'proximate determinants of fertility'* that directly affect fertility.

These eight variables are classified as: -

A. Exposure variable
   1. Marriage

B. Conception variables
   2. Use or Non-use of contraception
   3. Induced abortion

C. Determinants of natural fertility

4. Lactational Infecundability
5. Coital frequency
6. Spontaneous intrauterine mortality
7. Sterility
8. Duration of fertile Union

According to him, the variability in Total Fertility Rate (TFR) is primarily influenced by first 4 variables i.e. Marriage, Contraception, Induced abortion and Lactational Infecundability, while other factors contribute comparatively less to these fluctuations [10, 11].

2- Coale-Trussell Model of Marital Fertility:

This model was proposed by Ansley Coale and James Trussell (1974), that quantifies fertility patterns based on marital status and age. It is especially useful for comparing fertility behaviors across populations and assessing the level of fertility control within marriage.

The Coale-Trussell model introduces two main parameters to influence the standard pattern: **m** and **M** to measure fertility control level and overall fertility level.

The standard structure of the model is:

$$r(a) = M.n(a)\,.e^{m.v(a)}$$

Where

- **M (Fertility Index):** A multiplicative factor indicating the overall level of fertility relative to the model schedule.
- **m (Fertility Control Index):** Reflects the degree of fertility control, i.e., the extent to which couples deliberately limit childbearing.
- **r(a):** ASMFR under consideration
- **n(a):** Empirically derived standard natural fertility schedule
- **v(a):** An empirically derived function representing the typical age patterns of voluntary control of fertility (parity progression or approximates cumulative fertility).

If **m = 0**, indicates no fertility control and **m > 0**, indicates couples are spacing or stopping births [12].

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Understanding fertility trends and differentials by age, region, socioeconomic status, and cultural background is essential for designing and implementing effective population policies. Such analysis provides crucial evidence for formulating reproductive health strategies, family planning programs, gender-sensitive interventions, and long-term development planning. Therefore, a rigorous examination of fertility dynamics in India is indispensable for anticipating the country's demographic transition and ensuring sustainable socio-economic development, especially given its vast population and regional disparities in fertility trends.

Our study is designed to conduct an extensive statistical analysis of human fertility dynamics, utilizing nationwide data sources such as demographic surveys, census records, and fertility studies. It will highlight trends, regional disparities, contributing factors, and future predictions.

1.2 Review of literature (ROL):

Brahma and Basumatary (2023) analyzed fertility patterns and differentials in India using five rounds of NFHS data from 1992–93 to 2019–21. Their study examined how caste, religion, education, wealth index, residence, mortality factors, and other background characteristics influence total fertility rate across 25 states. They found clear fertility differentials, showing that social and economic factors strongly affect reproductive behavior. The authors also reported that contraceptive use, birth order, age at first marriage, birth interval, unmet need for family planning, and sex preference significantly determine fertility levels. Their panel data analysis showed large state-level variations in TFR over time [13].

Jena et al. (2023) analyzed age-specific fertility rates (ASFRs) in India using deterministic and non-deterministic statistical models. They applied polynomial regression and skew-normal regression to study fertility patterns among total, rural, and urban women using SRS-2020 and NFHS-5 data. The study found that fertility peaked in women aged 20–24 years and that the proposed models effectively described the distribution and variation in ASFRs. This research highlights the importance of statistical modeling to understand fertility behavior across different age groups and regions, providing useful methods for analyzing fertility dynamics in India [14].

Singh and Singh (2024) analyzed high-risk fertility behavior among Indian women using NFHS data and showed that risky fertility patterns such as early maternal age, short birth intervals, and high parity have decreased over time but still remain high in many states. Their study found that factors like wealth, education, caste, religion, age at marriage, mass-media exposure, contraceptive use, and ANC visits strongly influence fertility behavior. They used binomial and multinomial logistic regression to identify key predictors. This study highlights how socio-demographic and reproductive factors shape fertility patterns in India, providing useful insights for statistical exploration of human fertility in my thesis [15].

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Singh et al. (2024) analyzed wealth-based disparities in short birth intervals (SBI) among 109,439 Indian women using NFHS-5 data. They found that 47.8% of women experienced SBI, with higher prevalence among poorer mothers and significant state-wise variation. Multilevel logistic regression showed that age, caste, wealth, education, and child mortality were significant predictors of SBI. This study highlights socio-economic inequalities in fertility behavior in India [16].

Barik et al. (2025) examined the trends and socio-economic determinants of delayed motherhood in India using NFHS data from five rounds. The study focused on women aged 40–49 years and defined delayed motherhood as childbirth at age 35 or above. Using join point regression and age-period-cohort analysis, they found an increasing trend of delayed motherhood, particularly among women with higher education and from wealthier households, while lower socio-economic groups showed slower declines. This study highlights the demographic shifts in fertility patterns and the influence of socio-economic and educational factors on reproductive behavior, which is relevant for statistical exploration of fertility dynamics in India [17].

Bhojak and Jani (2025) analyzed long-term trends in fertility, family planning, and maternal health in India using NFHS-1 to NFHS-5 data. Their study showed a steady decline in the Total Fertility Rate and a gradual rise in contraceptive use over the years. They also found that institutional deliveries and skilled birth attendance improved significantly, indicating better maternal health services. The authors projected that these positive trends will continue in NFHS-6, with further increases in modern contraceptive use and near-universal institutional births [18].

On the basis of above references, fertility dynamics constitute a vital area of demographic research, particularly in the Indian context. Fertility patterns exhibit substantial regional variation across the country, shaped by a complex interplay of cultural practices, levels of education, economic disparities, and religious ideologies. These multifaceted determinants result in distinct reproductive behaviors among various states and communities, thereby underscoring the importance of a comprehensive and critically evaluated analysis of fertility dynamics.

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1.3 Significance of the Study:

In India, regional differences in fertility patterns are evident: The Southern regions of India like Kerala, Tamil Nadu, and Karnataka reached replacement-level fertility earlier than northern states. Such variation influences public health, education, employment, and resource planning. Existing studies often focus on national-level fertility indicators, but there is a growing need for sub-national analyses that account for state-specific cultural, economic, and healthcare disparities.

A statistical exploration of fertility dynamics can reveal underlying socio-economic, cultural, and health system factors influencing reproductive behaviour. This study will offer to a deep understanding of fertility pattern under the purview of the Demographic Transition Model (DTM) and support evidence-based decisions for managing population and development challenges in India.

1.4 Research Questions:

The following questions formed the basis of this study-

1. What are the trends and patterns of fertility indicators in India over time and across regions?
2. Which socio-demographic, economic, and cultural factors significantly influence fertility behaviour in India?
3. How do fertility patterns differ between rural and urban populations, and among various states in India?
4. How does the fertility transition in India compare with that of other countries at similar stages of development, and what global patterns or trends can be identified in fertility decline?
5. What statistical models best explain and predict fertility outcomes in the Indian context?
6. How accurately can fertility be predicted using various statistical models?
7. What are the implications of observed fertility dynamics for public health and population policy in India?

1.5 Problem Statement:

Problem statement of the present study is:

"The aim of this study is to analyze human fertility dynamics in context of India through the application of statistical methods and modeling, in order to identify key determinants, explore regional and socio-demographic variations, and provide predictive insights for population and health planning."

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2.0 OPERATIONAL DEFINITIONS & CONCEPTS:

Definitions of key terms:

- **Fertility:** The term "fertility" refers to a person's Actual birth performance
- **Demographic Analysis**: A scientific study of human populations, focusing mainly on their size, composition, and patterns of growth or change.
- **Demographic Transitions**: shifting of fertility and mortality patterns from high to low levels over time.
- **Population Growth/change:** It refers to fluctuation (increase or decrease) in population size in a given area over time. It is influenced by births, deaths, and migration
- **Population Balancing Equation:** It's a basic demographic equation that expresses population change through time, makes use of such measures.
  Change in population between time 1 and time 2 is: -

$$dP = P_2 - P_1 = B - D + I - O$$

Where,

P_2 is population at time 2, P_1 is population at time 1, **B** is births between time 1 and time 2, **D** is deaths between time 1 and time 2, **I** is in-migrants arriving between time 1 and time 2, **O** is out-migrants departing between time 1 and time 2.

- **Sustainable development:** It is a balanced approach to economic growth, social well-being, and environmental protection for present and future generations.
- **Population Structure**: The composition of a population based on factors like age, gender, and socio-economic characteristics, shaping societal and economic dynamics.
- **Facundity:** Biological capacity of women to reproduce or to conceive.
- **Natural fertility of population:** Fertility level when there is no use of any family planning methods.

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Measures of Fertility:

- **Crude birth rate (CBR)**: It is defined by the total no. of live births occurring per 1,000 individuals in a given year.

$$\text{CBR} = \frac{B}{P} \times 1000$$

Where,

B is No. of live births during the year

P is Mid-year population of that year

- **General fertility rate (GFR)**: It is defined by the total No. of live births occurring per 1,000 women of reproductive age (15–49) in a specific year.

$$\text{GFR} = \frac{B}{F_{15-49}} \times 1000$$

Where,

B is the total No. of live births in a year

F is the mid-year female population of child bearing age-group (15-49) in that year

- **General Marital fertility rate (GMFR)** = It is defined by total No. of live births occurring per 1,000 married women aged 15–49 in a specific year.

$$\text{GMFR} = \frac{B}{MF_{15-49}} \times 1000$$

Where,

B is the total no. of live births in a year

MF is married female population of child bearing age-group (15-49) in that year

- **Age-Specific Fertility Rate (ASFR):** Total Number of live births to per 1,000 females of a specified age group in a given year.

$$\text{ASFR} = \frac{B_x}{F_x} \times 1000$$

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Where,

B_x is total number of live births to mother of a specified age-group (x) in a year

F_x is Mid-year female population of the same age-group in that year

- **Age-Specific Marital Fertility Rate (ASMFR):** It is defined by the total No. of live births to per 1,000 married women of a specified age group in a given year.

$$\text{ASFR} = \frac{B_x}{MF_x} \times 1000$$

Where,

B_x is total number of live births to married women of a specified age-group (x) in a year

MF_x is Mid-year married women population of the same age-group in that year

- **Total Fertility Rate (TFR):** The average no. of children a woman would have in her lifetime based on current ASFRs

$$\text{TFR} = \frac{5 \times \sum_{15-19}^{45-49} ASFR}{1000}$$

- **Total Marital Fertility Rate (TMFR):** It indicates the average no. of children a married woman would have in her lifetime based on current ASMFRs

$$\text{TMFR} = \frac{5 \times \sum_{15-19}^{45-49} ASMFR}{1000}$$

- **Order Specific Fertility Rate (OSFR):** Number of births of order 'i' per 1000 women of child bearing age group

$$\text{OSFR} = \frac{B_i}{F_{15-49}} \times 1000$$

Where,

B_i is the number of births of order 'i'

$F_{15\text{-}49}$ is total number of women in age-group 15-49.

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*Note: $\sum OSFR = GFR$ i.e. $GFR = \sum_{i=1}^{n}(\frac{B_i}{F_{15-49}}) \times 1000$, Where n represents the maximum order of birth

- **Order Age Specific Fertility Rate (OASFR):** It indicates the no. of births of order 'i' to women of age 'x' per 1000 women of age 'x'

$$\text{OASFR} = \frac{B_{i(x)}}{F_x} \times 1000$$

Where,

$B_{i(x)}$ is the number of births of order 'i' to women of age / age group x

F_x is total number of women of age / age group x

*Note: $\sum OASFR_{i(x)} = ASFR_x$, Where $ASFR_x$ = Age specific fertility rate of order 'i' of age / age group x

- **Parity Progression Ratio (PPR):** It quantifies the likelihood of women moving from one birth order to the next. In other words, chance for a woman of parity 'i' to go for higher parity (to have additional child) in a year.

$$\text{PPR for Parity i, } a_i = \frac{No.of\ Women\ of\ at\ least\ \ (i+1)\ parity}{No.of\ Women\ of\ at\ least\ \ i\ parity}$$

- **Child Women Ratio (CWR):** The ratio of children under age 5 to women of childbearing age is

$$\text{CWR} = \frac{No.of\ Children\ under\ age\ 5}{No.of\ Women\ in\ reproductive\ age\ group} \times 1000$$

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Measures of Reproduction:

- **Gross Reproduction Rate (GRR):** It is the average no. of daughters a woman would bear during her reproductive years, assuming no female mortality.

For 5-year age data:

$$GRR = 5 \times \sum_{x=15}^{45} f_x^w = 5 \times \sum_{x=15}^{45} \frac{B_x^f}{F_x}$$

$$x = 15, 20, 25 \ldots 45$$

Where ,

B_x^f is the no. of female live births to mothers of the age x to x+5

F_x is the mid-year total females of the age group x to x+5

f_x^w is the no. of female births per women of age group x to x+5

- **Net Reproduction Rate (NRR):** NRR is the average number of daughters a woman would have during her lifetime **who survive to the age of reproduction**, considering age-specific mortality and fertility rates.

For 5-year age data:

$$NRR = 5 \times \sum_{x=15}^{45} f_x^w \times \frac{L_x^w}{l_0} = 5 \times \sum_{x=15}^{45} \frac{B_x^f}{F_x} \times \frac{L_x^w}{l_0}$$

$$x = 15, 20, 25 \ldots 45$$

Where,

f_x^w is the age specific fertility rate considering only female births

$\frac{L_x^w}{l_0}$ is the No. of person years per women in the hypothetical cohort (taken from female life Table)

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Some Statistical models:

Regression Analysis: Regression analysis is a statistical technique used to predict continuous outcomes or numerical values based on input variables. Various methods, including linear, multiple, logistic, and polynomial regression, help model relationships between variables effectively.

1. **Simple Linear Regression Model:** It is used to study the relationship between 1 dependent variable and 1 independent variables by fitting a straight line through the data.

It is formulated as:

$$Y = \beta_0 + \beta_1 X + \varepsilon$$

Where,

- **Y** = Dependent (response) variable,
- **X**= Independent (predictor) variable,
- $\boldsymbol{\beta_0}$ = Intercept (value of Y when X=0),
- $\boldsymbol{\beta_1}$ = Slope (change in Y for a one-unit change in X),
- **ε** = Random error term

2. **Multiple linear Regression Model:** Used to study the mathematical relationship between 1 dependent variable and more than 1 independent variables by fitting a straight line through the data.

It is formulated as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_K X_K + \varepsilon$$

Where,

- $\boldsymbol{X_2 \ldots\ldots, X_K}$ = *Independent variable* ,
- $\boldsymbol{\beta_1, \beta_2 \ldots\ldots, \beta_K}$ = Coefficients showing the effect of each predictor
- **ε** = Random error term

3. **Logistic Regression Model:** Logistic regression is a statistical method used to find out the mathematical relationship between a binary outcome (0 or 1) and one or more independent variables.

It is formulated as:

$$logit(p) = ln\frac{p}{1-p} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_K X_K + \varepsilon$$

Where:

- p = Probability that the outcome is 1
- 1-p = Probability that the outcome is 0
- $\frac{p}{1-p}$ = Odds of the event occurring
- β_0 = Intercept
- $\beta_1, \beta_2 \ldots\ldots\ldots\ldots, \beta_K$= Coefficients of independent variables
- $X_1, X_2 \ldots\ldots\ldots\ldots, X_K$= Predictor variables

3.0 RESEARCH OBJECTIVES:

The objectives of the present study are as follows-

1. To analyse the current fertility levels and their regional variations in India.
2. To analyze fertility rate trends by comparing current nationwide secondary data with previous rounds of data
3. To compare India's fertility transition with other countries and explore global trends.
4. To identify and model the socio-economic and demographic determinants influencing fertility
5. To analyse the impact of family planning awareness (use of contraceptive etc.) on fertility outcomes
6. To build statistical models for predicting fertility outcomes using key indicators.
7. To evaluate the implications of fertility patterns for population growth and development planning.

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4.0 HYPOTHESIS (Assumptions):

Research (alternative) hypothesis of this study are-

1. There are significant regional variations in fertility levels across Indian states.
2. Fertility rates in India have declined significantly over recent decades.
3. India's fertility transition follows a similar pattern to that of other developing countries
4. Socio-economic and demographic factors significantly influence fertility levels in India.
5. Public health and family planning interventions have a significant impact on fertility reduction.
6. Predictive statistical models using socio-economic, demographic, and health indicators can significantly predict the fertility outcomes.
7. Current fertility patterns have significant implications for future population growth and demand for health, education, and employment services.

5.0 MATERIALS & METHODS

5.1 Research design:

The study design will be **Cross-Sectional, Analytical** Research Design.

5.2 Research Methods:

We will use "**Quantitative research methods**" for our study.

5.3 Sample and Sampling Techniques:

We will use appropriate probability or non-probability sampling technique.

5.4 Data collection procedure:

In this study we will use nationally representative secondary data sources.

5.5 Data Sources:

Fundamental Data Source

NFHS (National Family Health Survey (NFHS), conducted by the International Institute for Population Sciences (IIPS) under the Ministry of Health and Family Welfare (MOHFW), Government of India) provides nationally and state-wise representative data on fertility, family planning, reproductive health and associated socio-economic indicators.

Supporting data Sources

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Sample Registration System (SRS) Published annually by the Office of the Registrar General of India, provides reliable and continuous estimates of key fertility indicators such as the Crude Birth Rate (CBR), Total Fertility Rate (TFR), and Age-Specific Fertility Rates (ASFR) across states and regions in India.

The District Level Household and Facility Survey (DLHS), carried out by the Ministry of Health and Family Welfare, offers detailed information on fertility-related indicators, family planning, maternal health, and healthcare facilities at the district level, helping to assess regional variations

The Census of India, conducted in every 10 years, offers detailed data on population size, age distribution, literacy, and other socio-economic factors. It helps in understanding the demographic background related to fertility trends in India

The World Population Prospects (WPP), published by the United Nations, gives global data on fertility and population trends. It helps compare India's fertility situation with that of other countries worldwide etc.

5.6 Variables Under Study:

Dependent Variable (Outcome):

Fertility indicators: Number of children ever born (CEB), Total Fertility Rate (TFR), Births in the last 3/5 years, Age-specific fertility (for married women) etc.

Independent Variables (Predictors):

a. Demographic Variables: Age, Age at marriage, Region/state, Urban/rural residence

b. Socio-economic Variables: Woman's education level, Husband's education level, Wealth index, Employment status, Caste and religion etc.

c. Health & Family Planning Variables: Contraceptive use (modern/traditional), Exposure to mass media, Access to health services, Unmet need for contraception etc.

d. Household/Community Level Variables: Household size, Number of living children, Sex of children, Decision-making power in the household etc.

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6.0 DATA ANALYSIS & STATISTICAL TECHNIQUES:

In the study we will use several tools and techniques for gathering & analyzing the data, and interpreting of results.

6.1 Statistical tools:

Data will be analyzed by using the proper statistical tools such as-

- **SPSS (Statistical Package for the Social Sciences): Software for data analysis.**
- **R Programming: Open-source programming for statistical computing and** graphics.
- **Excel**: Basic statistical analysis and data visualization.

6.2 Statistical techniques:

- Graphical Representation, Trends
- Descriptive and inferential statistical techniques
- Bivariate analysis (Chi-square etc.)
- Multivariate regression model: logistic, poisson, negative binomial
- Predictive modelling and Other appropriate statistical models will be used.

7.0 DELIMITATIONS AND SCOPE OF THE STUDY:

7.1 Delimitations:

Demographic model research provides insightful information about population dynamics it comes with certain limitations and challenges, they are as below:

1. Data Source Limitation

This study relies exclusively on secondary data obtained from the National Family Health Survey (NFHS), which may limit the scope of variables and depth of information available. In many cases, data may be incomplete. This can affect the accuracy, precision, dependability and reliability of fertility analyses.

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2. Population Focus

The analysis is confined to women in the 15–49 age (reproductive age group), excluding data on male fertility and fertility patterns in other age groups.

3. Quantitative Data Only

Only quantitative data from the NFHS are utilized, which excludes qualitative insights into cultural, social, or personal factors affecting fertility behaviour.

4. Time Frame

The study is limited to a specific round of NFHS data, restricting the ability to analyse fertility trends over longer periods or conduct longitudinal analysis.

5. Sampling Frame

Certain groups such as institutionalized populations or those outside the NFHS sampling frame are not included in the analysis.

6. Secondary Data Limitations

The study depends on the accuracy, completeness, and reliability of the data and is subject to any reporting biases or data entry errors inherent in the source.

7.2 Scope of the study:

The scope of this study encompasses a comprehensive statistical investigation into fertility patterns and trends across India, drawing upon nationally representative secondary data to uncover key demographic insights. The study spans multiple dimensions of fertility dynamics and their socio-economic determinants, as outlined below:

1. **Foundational framework:** The study explores foundational demographic concepts related to fertility such as Total Fertility Rate (TFR), Age-Specific Fertility Rate (ASFR), and replacement-level fertility while grounding the analysis in robust statistical techniques and demographic theories.
2. **Multi-sectoral Relevance:** Fertility is not merely a biological phenomenon but intersects with public health, women's education, economic participation, and social development. This study analyses how fertility levels relate to broader developmental indicators across Indian states and regions.

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3. **Thematic Focus Areas:** The core themes examined include regional variations in fertility, socio-economic and cultural determinants, urban-rural disparities, female autonomy and literacy, contraceptive use, and access to healthcare—all of which are pivotal in shaping fertility outcomes.

4. **Data-Driven Approach:** Using the most recent round of a nationally conducted household health survey, the study leverages quantitative data to perform statistical modeling, including regression analysis and predictive modeling, to uncover fertility determinants and forecast trends.

5. **Interdisciplinary Integration:** The research draws on insights from demography, statistics, public health, and social sciences, highlighting the interdisciplinary nature of fertility analysis and its implications for evidence-based policy and planning.

6. **Comparative Insights:** The study compares fertility trends across different Indian states and socio-demographic groups (e.g., education levels, income quintiles, religious and caste groups), offering insights into differential fertility behaviours and transitions.

7. **Technological and Methodological Advancements:** The study incorporates modern statistical tools and software for data cleaning, visualization, and model building, thereby enhancing the precision and interpretability of fertility research

8. **Policy and planning implications:** This study's findings are expected to support targeted policy-making in areas such as reproductive health, family planning, and women's empowerment. By identifying high-fertility pockets and their drivers, the study offers useful and applicable ideas for achieving demographic goals and sustainable development.

This study offers a multi-dimensional, data-rich, and statistically grounded exploration of fertility dynamics in India. It addresses a critical demographic aspect with far-reaching implications for population stabilization, human development, and equitable resource allocation.

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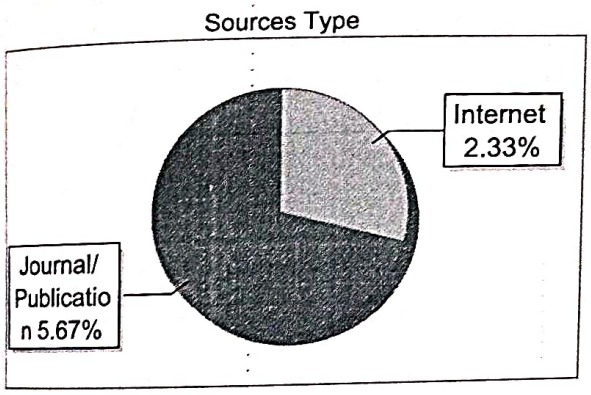

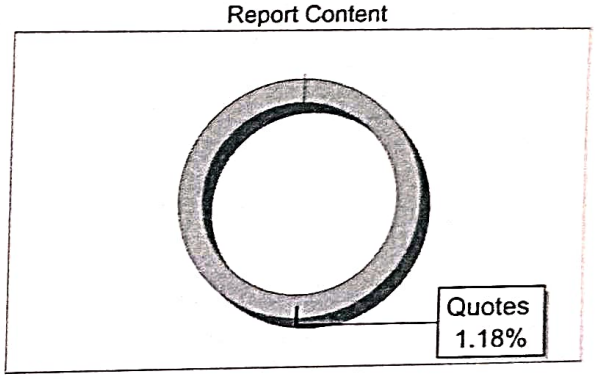

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